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ON THE STRATIGRAPHIC POSITION AND AGE OF THE JUDITH RIVER FORMATION

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For some years there has been a suspicion in the mind of the writer that perhaps, after all, the older geologists were correct in their views as to the position of the Judith River beds in their relation to the previously recognized, undisputed Fort Union formation, i.e., that the Judith River beds were immediately below the Fort Union formation. This view was strengthened when, in 1909, plants of undoubted Fort Union age were brought in from supposed "Judith River beds" on Big Sandy Creek, about fifty miles northwest of the mouth of the Judith River, by members of the U.S. Geological Survey, and confirmed upon a careful study and review of the evidence furnished by stratigraphic, vertebrate, and invertebrate data as detailed by Stanton and Hatcher in their work² and by Dr. O. P. Hay's paper "Where Do the Lance Creek (Ceratops) Beds Belong?"³ It is the purpose of the present paper to show that the Judith River beds are of Eocene-Tertiary age, and not of Belly River (Cretaceous) age, and are to be correlated with the Lower or somber portion of the Fort Union formation as defined and described by Knowlton,⁴ now known as the Lance formation.

Nearly forty years ago, or, to be more exact, in 1875,⁵ the writer, in attempting to correlate the Cretaceous and Tertiary formations in connection with work of the Hayden Survey in Colorado, took up the consideration of the Judith River beds, and among other

¹ Published by permission of the secretary of the Smithsonian Institution.

² *Bull. U.S. Geol. Surv.*, No. 257, 1905.

³ *Proc. Indiana Acad. Sci.*, Twenty-fifth Anniversary Meeting, 1909.

⁴ The "Stratigraphic relation and paleontology of the 'Hell Creek beds,' 'Ceratops beds,' and equivalents, and their relation to the Fort Union formation."—*Proc. Wash. Acad. Sci.*, XI, No. 3, pp. 179-238.

⁵ *U.S. Geol. and Geog. Surv. Terr.*, 1874, Washington, 1875, pp 154, 155.

conclusions, made the statement that the Judith River beds lie immediately below the Fort Union (as then known), and have their equivalent in Colorado, occupying there the same position as in Montana. He also stated that he believed them to be of Cretaceous age, and thought that they formed either the upper part of the Fox Hills, or a group to be called No. 6, the Fox Hills being known as No. 5.

This opinion as to the Cretaceous age of the beds was based upon the study of the vertebrates by Professor E. D. Cope, a position which has been taken by all vertebrate paleontologists, both in the United States and in Canada. From this opinion the writer, in the light of what is known today, which will be briefly detailed below, dissents, and wishes to express here the conviction that the Judith River beds are of Eocene age. He, however, holds to his previous view that they do lie between the Fox Hills and the Fort Union formations as then known and described. This is why they were so generally referred to the Laramie. This is the position that has been assigned them by everyone who has studied them from the time they were first noted by Hayden in 1853-55, and named by him in 1871, down to the time of the investigations by Hatcher, who was the first (in 1902)¹ to assign them to a position in the Montana Cretaceous lower than that of the Fox Hills. In 1896, however, Hatcher had considered the Judith River beds as representing the lower 400 feet of strata at the base of the Ceratops beds of Converse County, Wyo., and just above the Fox Hills sandstone. This position above the Fox Hills coincides with that assigned them by Hayden, Meek, Cope, and Osborne, and by the writer, as just stated. The position indicated for the beds by Hatcher, in 1902,² is that assigned them by Stanton and Hatcher in 1905, and their views are fully elaborated in their bulletin³ published by the U.S. Geological Survey.

The historical aspect of this question has been so thoroughly and most admirably stated by Stanton and Hatcher in the bulletin just cited, and it is only necessary to recapitulate enough to show that the statement made above is correct.

¹ *Science*, XVI, 831, 2.

² *Ibid.*, XVIII, 211.

³ *Bull. U.S. Geol. Surv.*, No. 257, 1905.

In 1861 Meek and Hayden, after referring to the early conflicting views as to the age of the Judith River beds, say:¹ "They are really of Tertiary age, and hold a position at the base of the great lignite series [Fort Union formation] of the northwest." In 1871² Hayden gave these deposits the name "Judith group," and says:

The sediments do not differ materially from those of the Fort Union group, and they contain impure beds of lignite, fresh-water mollusca, and a few leaves of deciduous trees. But the most remarkable feature of this group is the number and variety of the curious reptilian remains of which we have only yet caught a glimpse.

As to the age of the underlying sandstones near the mouth of the Judith River, concerning which there had previously been some doubt, both Meek³ and Hayden⁴ in 1875, independently of each other, correlated them with the Fox Hills, Meek saying that "we cannot be far wrong in regarding the latter beds [the marine Cretaceous beds at the mouth of Judith River] as holding a position at the horizon of the top of the Fox Hills." Cope,⁵ in 1874, in a "review of the vertebrata of the Cretaceous period found west of the Mississippi River," in a notice of the Judith River beds under the head of the Fort Union or lignite group, says: "From the standpoint of the writer, these beds would be at the top of the Cretaceous and more or less related to the Fort Union epoch." After the early explorations by Hayden, the first geological examination of the Judith River country was made by Edward S. Dana and George B. Grinnell⁶ in the summer of 1875. They made a short excursion to the mouth of the Judith River and spent two days in this locality. They speak of their results being, of course, meager. "Enough,"⁷ however, was seen to establish the age of the beds at this point as beyond a doubt Cretaceous, three members of this division of Meso-

¹ *Proc. Acad. Nat. Sci.*, 1861, p. 415, footnote.

² F. E. Hayden, *Preliminary Report, U.S. Geol. Surv. Wyoming*, Washington, 1871, p. 97.

³ *Bull. U.S. Geol. and Geog. Surv.*, I, 2d series, No. 1, p. 39.

⁴ *Ibid.*, p. 403.

⁵ *Bull. U.S. Geol. and Geog. Surv.*, 1874-75, I (1875), 1st series, p. 6.

⁶ Geological report in Ludlow's report of a *Reconnaissance from Carroll, Montana, on the Upper Missouri, to the Yellowstone National Park and Return*, Washington, 1876.

⁷ *Ibid.*, p. 124.

zoic time having been found there and identified by fossils." The three members referred to were No. 4, Fort Pierre, No. 5, Fox Hills, and No. 6, Fort Union. The thickness of the latter was estimated at 400 feet, and the strata are described as beds of white sandstone containing occasional layers of a clayey brown sand rock, "at the mouth of the Judith River, evidently overlying the beds of No. 5 [Fox Hills] before referred to." From these beds they obtained the vertebrae and long neck bones of dinosaurs identified by Professor Marsh as belonging very near the genus *Hadrosaurus* [Trachodon] of Leidy. With these remains were found Unios and, in some layers, a little lignite, the general association seeming to refer the deposits to the Fort Union beds.

Professor E. D. Cope was the next to visit the region. In the summer of 1876 he explored the region near the mouth of the Judith River and eastward as far as Armel's Creek, 130 to 150 miles to the eastward from Fort Benton. He fully corroborated Hayden's observations and his sections are substantially the same. He regarded the Judith River beds as Cretaceous, with Tertiary affinities,¹ and referring to their position, says:² "In the Judith region the relation of the Fox Hills sandstone to the superincumbent strata is everywhere observable." "The ferruginous, soft sandstone of the Fox Hills group is everywhere the line of demarkation between the black shales of No. 4 [Fort Pierre] below and the Judith River beds above."³

The last identification of fossils made by Professor F. B. Meek was for Professor Cope. The fossils were *Inoceramus barabini*, *Inoceramus* sp.; and *Baculites compressus*, and were obtained by Cope⁴ from the black shales of No. 4. Although Meek had not revisited this region, his last word on the Judith River beds is interesting and illuminating.⁵ Basing his opinion upon the invertebrates found in the beds immediately underlying the Judith River beds near the mouth of the Judith River, he correlates them with the upper part of the Fox Hills.⁶ As to the Judith River group,

¹ *Bull. U.S. Geol. and Geog. Surv.*, III (1877), 569.

² *Ibid.*, p. 568.

³ *Ibid.*

⁴ *Ibid.*

⁵ *Report of U.S. Geol. Surv. Terr.*, IX (1876).

⁶ *Ibid.*, p. xxxvi.

which he believes to be somewhat extended in the upper Missouri River region at the base of the Fort Union group, he suggests the probability of its Cretaceous age, but says: "Yet this can scarcely be properly regarded as an established fact,"¹ and then refers to the mingling of the Eocene and Cretaceous types of vertebrates in the beds.

During the summer of 1882 Dr. C. A. White² made a special study of the geology about Fort Union and the region extending thence up the Yellowstone. He ascertained as the result of this study that, with the exception of one or two small exposures of the Fox Hills lying immediately below the Fort Union [which he referred to the Laramie], the latter occupied the whole region and from the beds so referred the collected fossil plants, fresh-water invertebrates, and dinosaurian remains, and states that the latter are found toward the base [that is, in the beds since referred to the Lance formation].

The following year Dr. White³ spent part of the months of July and August in the area between Fort Benton and Judith River and the Highwood Mountains studying the relations of the Laramie [Lance?] group to the underlying formations. He was joined here by Professor L. F. Ward⁴ and on August 22 they began the descent of the Missouri from Fort Benton to Bismarck, which they reached September 21. Ward says that the most notable fossil plant locality discovered was about 7 miles below Coal Banks on the right bank of the Missouri River, occupying a stratigraphic position near the base of the Fox Hills, probably in the Fort Pierre group. These were of special interest as being the only Cretaceous fossil plants found up to that time in the United States above the Dakota group. White and Ward as the result of this trip saw no reason to differ with the latest conclusions of Meek and Hayden, or those of Cope, but, as Dr. Stanton⁵ says, their stratigraphic observations were never fully published. Later, White⁶ in dis-

¹ *Ibid.*, p. l-li.

² *Am. Jour. Sci.*, 3d ser., xxvii (1883), 121.

³ *Fifth Ann. Rept. U.S. Geol. Surv. for 1883-84-85*, p. 50.

⁴ *Ibid.*, p. 60.

⁵ *Bull. U.S. Geol. Surv. No. 257*, p. 27.

⁶ *Ibid.*, No. 82, pp. 174-77.

cussing the Belly River formation, refers to the identity or close resemblance between the Belly River beds and the fresh-water Laramie [Lance] (which included at that time the Judith River beds) and suggests the gradual coming-in of the Belly River series between the Colorado and Montana, and the gradual thinning-out of the Montana until the Laramie [Lance] occurs, resting immediately upon the Belly River, the two blending, with the Montana absent. He says, however: "It is true that no observation has yet been made of a complete thinning-out of the Belly River formation in any direction, nor of its blending with the Laramie [Lance] by the absence or by the thinning-out of the Montana formation."¹

Dr. White² recognized the fact that both the Belly River series and the Laramie [which as he used it included the Lance and the Judith River beds] rest upon marine Cretaceous and says also: "Unlike the Laramie [Lance], the Belly River formation is immediately overlain, as well as underlain by marine Cretaceous strata." The latter he says are undoubtedly referable to the Montana formation. He says further:³ "What gives this formation [Belly River] especial interest is the intimate relation of its fauna and flora to those of the Laramie [Lance], although these two non-marine formations are, in the district within which both are now known to occur, separated by a great thickness of strata which are unmistakably of marine origin." Although Sir J. W. Dawson⁴ has stated that the flora of the Belly River series very closely resembles that of the Lower Laramie [Lance] we shall see later on that such resemblance as exists is not very striking. In regard to the survival of the molluscan fauna he concludes that "the fresh-water habitat of the Belly River molluscan fauna was shifted by subsidence and gradual filling of aqueous areas."

In 1894 Dr. Stanton spent a few days with Mr. W. H. Weed near the mouth of Judith River. They traveled by rowboat down the Missouri River from Fort Benton to Judith, passing over and studying the formations underlying the Judith River beds, beginning with Fort Benton shales. Dr. Stanton confirmed the statements of previous observers that some of the strata beneath the Judith River beds contain a fauna that is elsewhere characteristic of the

¹ *Bull. U. S. Geol. Surv.*, No. 257, p. 176. ² *Ibid.*, p. 174. ³ *Op. cit.*, p. 175.

⁴ *Trans. Roy. Soc. Canada*, III, sec. IV (1885), p. 20.

Montana group, or Fort Pierre and Fox Hills formations. He was especially impressed by the occurrence, in the upper part of these underlying beds, of a zone containing *Cardium speciosum*, *Mastra alta*, *Tancredia americana*, and other forms which in north-central Colorado are known to occur only in the Fox Hills beds immediately beneath the Laramie. No beds higher than the Judith River were seen, and the view was adopted that the Judith River series overlies all of the Montana group and is referable to the Laramie. When a few days later the overlying marine Cretaceous shales were seen in contact with upturned Judith River beds near Havre, Mont., their apparent position was supposed to be due to faulting, of which there was abundant evidence in the neighborhood.¹

As a result of this work Dr. Stanton² gave Mr. Whitman Cross the following section made in Dog Creek, published in 1896:

The fresh-water Judith River beds are well exposed in bluffs on Dog Creek, 4 or 5 miles from the mouth of Judith River, and also on the north side of the Missouri within 3 or 4 miles of the same place. The section in this neighborhood shows about 650 feet of marine Cretaceous strata overlain by 300 to 350 feet of fresh-water beds. The succession of strata and thickness as estimated by Mr. W. H. Weed are as follows, beginning at the base:

1. Soft, dark clay shales.
2. Band of ferruginous sandstone with *Avicula linguiformis*, *Inoceramus crispus*, *Baroda wyomingensis*, *Platoniceras placenta*, etc.
3. Shales like No. 1.
4. Coarse gray laminated sandstone.
5. Carbonaceous shales with bed of lignite at base. 100
6. Brown sandstone with great numbers of *Cardium speciosum* and a few other species 30
7. Sandy shales 25
8. Dark clay shales with concretions containing *Baculites ovatus* in lower portion and sandy bands and concretions near the top with a characteristic Fox Hills fauna including:

Nucula sp.	<i>Liopistha</i> (<i>Cymella</i>) <i>undata</i>
<i>Clisocolus cordatus</i>	<i>Pholadomya subventricosa</i>
<i>Callista nebrascensis</i>	<i>Mastra formosa</i>
<i>Tellina aequilateralis</i>	<i>Lunatia subcrassa</i>
<i>Tancredia americana</i>	<i>Baculites ovatus</i>

The total thickness of this bed was not seen at any one place, but it is at least 350 feet.

Immediately above these dark shales is a bed of greenish-yellow sandstone which occasionally forms bluff exposures 50 or 60 feet high, but usually only slightly exposed in steep slopes and largely covered by wash from the softer and lighter-colored beds above. This was taken as the dividing line between

¹ Stanton and Hatcher, *Bull. U.S. Geol. Surv.*, No. 257, 1905, p. 10.

² *Monographs U.S. Geol. Surv.*, XXVII (1896), 239-41.

the marine and fresh-water beds, though no fossils excepting silicified wood were found in the lower 200 feet of the latter. The remainder of the section, about 300 feet in thickness, is apparently conformable with the underlying beds, but is quite distinct from them in color and texture. It consists of alternations of light-colored, soft, friable sandstones, clays, and marls, with some seams of lignite and purplish carbonaceous bands. Fossils are abundant in the upper 200 feet, consisting of fragments of silicified wood, bones, and numerous invertebrates. The latter include the following species:

<i>Sphaerium recticardinale</i>	<i>Goniobasis sublaevis</i>
<i>Sphaerium planum</i>	<i>Goniobasis subtortuosa</i>
<i>Unio danae</i>	<i>Goniobasis</i> sp. closely related to <i>G. tenuicarinata</i>
<i>Unio cryptorhynchus</i>	<i>Campeloma vetula</i>
<i>Anodonta propatoris</i>	<i>Vetrina</i> ? <i>obliqua</i>
<i>Viviparus conradi</i>	<i>Physa copei</i>
<i>Helix veternus</i>	

At the top of the exposure above these fresh-water beds there is a band of brackish-water fossils, reported by both Meek and Hayden and by Cope, which contain *Ostrea subtrigonalis*, *Anomia* sp., *Corbicula occidentalis*, *Corbula cytheriformis*, *Goniobasis convexa*, etc. This band was not seen by me in the neighborhood of Judith River, but I afterward saw it near Havre, Mont., holding the same position above the fresh-water beds.

Cross, in commenting on this section, refers to the specific identity of the brackish-water shells found by Stanton on Dog Creek and near Havre with those found by Weed in the Livingston¹ beds, saying their presence does not indicate the Laramie (by which he means true Laramie as found in Colorado) age of the Judith River beds, and as to the apparent conformity with the Fox Hills urges for the Judith River beds the same considerations as he did in discussing the Converse County beds (now called the Lance) in Wyoming. These as given on p. 236 are as follows:

There are many places in the West where the section of visible sedimentary formations from the Cambrian to the Cretaceous seems a conformable one, and it has frequently been spoken of as such, but the researches of the last two decades have proven the existence of many important stratigraphic breaks in this series, which are in certain places shown as great unconformities but cannot be identified at other points. Especially in the plains country adjacent to the Rocky Mountains conformity of formations cannot be assumed to prove continuity of sedimentation. The visible conformity between the Ceratops

¹ The Livingston age of these beds was afterward denied by Dr. Stanton and others, but the point the writer wishes to make here relates more especially to the unconformity.

beds and the Fox Hills in Converse County cannot be accepted, contrary to other evidence, as proving the former to have been deposited in the epoch next succeeding the Fox Hills.

It is apparent from what has been quoted above that Dr. Stanton, when he went with Weed in 1894 from Fort Benton to the Judith River, found the Judith River beds in the type region in their normal position and that he was correct in assigning them to the stratigraphic position immediately overlying the Montana formation which, in its upper portions, contained a Fort Pierre and Fox Hills fauna. It was only when he got into the disturbed region near Havre, Mont., that he found marine Cretaceous shales overlying what he called "Judith River beds" and his explanation, that their apparent position *when so found* was due to faulting, was probably also correct.¹ Of course these beds exposed at Havre were not the real Judith River but the true Belly River series which normally underlies the Pierre as exposed in Canada north of this region. These beds were again examined by Dr. Stanton when with Hatcher in 1903. Their field studies were begun at this point, Milk River at Havre, and they

examined the excellent exposures along that stream to the international boundary, and beyond to Pendant d'Oreille Police Barracks, which is near one of Dawson's described localities, where the base of the Belly River beds is seen resting on the marine "lower dark shales." This is near Lake Pakowki of the maps, locally known as "Badwater Lake." We also examined the exposures of upper Belly River beds showing contact with the overlying "Pierre shales" on Sage Creek, Canada, as described by Dawson and McConnell, and continued our observations as far north as the Cypress Hills, where the top of the overlying marine Cretaceous is seen. Passing down Milk River below and around the eastern end of the Bearpaw Mountains to Cow Creek and the Missouri River at Cow Island and thence up Dog Creek, Judith, and Eagle Creek, Mont., we have studied the typical areas of the Judith River beds described by Meek and Hayden, and of the Eagle formation described by Weed. . . .

We have become fully convinced that the Belly River beds are identical with the Judith River beds, as Dawson long ago suggested. Our conclusion

¹ Dr. Stanton's exact words are as follows: "When a few days later the overlying marine cretaceous shales were seen in contact with upturned Judith River beds near Havre, Montana, their apparent position was supposed to be due to faulting of which there was abundant evidence in the neighborhood."—*U.S. Geol. Surv. Bull.*, No. 257, p. 10.

is based on lithologic character, stratigraphic sequence, the vertebrate and invertebrate faunas of the beds themselves, as well as on the paleontology of the underlying and overlying beds in both Canada and Montana.¹

In discussing in another place² the areas in which Judith River beds occur, Stanton and Hatcher refer to the exposures near Havre, the eastward extent of which they did not determine, and say:

It is very *probable* that this area is connected with the Cow Creek area by almost continuous exposures across the divide separating the drainage of the Missouri from that of Milk River east of the Bearpaw Mountains. On our journey from Havre to Cow Creek we passed through the eastern foothills of these mountains and crossed several areas of igneous rocks, but on Bean Creek near Lloyd post-office we saw outcrops apparently belonging to the Judith River beds, and *if our route had been a few miles farther east we could probably have had the formation in sight all the time.*³

This statement is a pure assumption, for it is evident that the beds were not traced continuously from the Milk River area to the vicinity of Cow Creek on the Missouri River, and the probabilities are that in this region to the eastward the distinction between the Belly River and the Judith River formations and not their identity would have been clearly shown. It is more than probable that here is the point where the supposed correlation fails. The Belly River, the Judith River, the Lance, and the Fort Union formations all have their representatives in this area, which is one of great disturbance due to faulting and the occurrence of volcanic intrusions. The lithological resemblance between the strata of these formations has been noted by all who have seen them, not only in this region, but to the southward and also northward in Canada. The relations of the beds in this disturbed area will be determined only after a most careful investigation of the country surrounding the Bearpaw Mountains, extending far enough away from the mountains to give normal undisturbed sections which can be closely studied. A careful stratigraphic tracing of these beds in the undisturbed region, which cannot be made in a flying trip across the country, will also be necessary, together with accurate paleontologic collections and their careful study.

¹ *Science*, N.S., XVIII (1903), 211-12.

² *Bull. U.S. Geol. Surv. No. 257*, 1905, p. 61.

³ The italics in this quotation are those of the present writer.

Study by Hatcher of the vertebrate collections made by him in 1882 and 1883 from the Judith River beds led him to the conclusion that this vertebrate fauna was older than Laramie fauna of the uppermost Cretaceous. By Laramie as used by Hatcher, it must be remembered, is meant the Ceratops beds, now called the Lance formation, which in the writer's opinion has been conclusively shown by Knowlton¹ to be of Lower Fort Union (Eocene) age. Hatcher was confirmed in his views by finding marine Cretaceous shales apparently overlying the Judith River beds. It must be again recalled in this connection that this was an area of complicated folding and great disturbances, the result mainly of numerous faults recognized by all who have been in the region from the time of Hayden's first explorations to those of Hatcher and Stanton. The latter says:²

"No better description of the frequency of these disturbances and the difficulties they have caused the stratigrapher can be given than that of Dr. Hayden," whom he quotes. The latter part of this quotation is as follows: "So much are the beds disturbed by forces acting from beneath that it seems almost hopeless to obtain a section showing with perfect accuracy the order of superposition of the different strata."

In 1896 Hatcher made the statement that the Judith River beds were certainly older than the Ceratops beds of Converse County, Wyo., and that "the dinosaurs from the Judith River country belonged to smaller and less specialized forms than those from the latter locality," and refers in the same article to his belief that "the Judith River beds are the equivalent of the 400 feet of barren sandstones, thus lying between the base of the Ceratops beds and the marine Fox Hills sandstones in Converse County, Wyo." Later, he repeats³ this statement and adds: "I am at present of the opinion that they pertain to a still lower horizon."

In the early part of 1903 Hatcher says he "believes the exact stratigraphical position of the Judith River beds remains unsettled and that it is premature to assert that the true Judith River beds

¹ Knowlton, *Proc. Wash. Acad. Sci.*, XI (1909), No. 3, pp. 179-238; and *Jour. Geol.*, XIX (May-June, 1911), 358-76.

² *Bull. U.S. Geol. Surv. No. 257*, 1905, p. 34.

³ *Science*, N.S., XVI (November 21, 1902), 832.

certainly overlies the Fort Pierre and are of more recent age, although this is now very generally believed and may eventually prove to be the case."¹

During the summer of 1903 Mr. Hatcher and Dr. Stanton spent two months in the field study of the Judith River formation; part of the time in the Judith basin. The results of their investigations were published in *Bulletin of the U.S. Geological Survey No. 257*, 1905. In a preliminary statement published in August, 1903,² they restate their belief that the Judith River beds occupy a lower position than had usually been assigned them and give a summarized section which divides the Montana into four formations in ascending order as follows: Eagle formation, Claggett formation, Judith River beds, and Bearpaw shales. As to the beds which are supposed to overlie the Judith River beds and for which the name Bearpaw shales is proposed they say:

They have the lithologic and faunal characters of the typical Pierre but represent only a fraction of that formation as usually understood. Beneath the light-colored mostly non-marine Judith River beds, is another formation 400 feet in thickness, which in its lower half resembles the Bearpaw shales and yields a few of the same species of fossils. Its upper 200 feet, however, contain several sandstone beds which bear a fauna that has hitherto been called "Fox Hills." We propose the name *Claggett formation* for these shales and sandstones underlying the Judith River beds.

Having in mind the possibility, if not the great probability, that the two series of beds, Belly River, and the Judith River with which the former was correlated by Stanton and Hatcher, were not one and the same, but were entirely distinct formations, and that the latter is really the equivalent of the division of the Fort Union to which the name Lance has been applied by the U.S. Geological Survey, the writer decided to visit the area in which the typical Judith River beds are exposed, and in accordance with this decision the month of July, 1911, was spent in this area in company with Mr. A. C. Silberling, formerly connected with the Carnegie Institute of Pittsburgh, and Professor G. L. Wait, of the Lewistown

¹ *Science*, N.S., XVIII (March, 1903), 472.

² *Ibid.*, (August 14, 1903), 211, 212. The article was sent in from the field from Judith Mountain.

High School, whose familiarity with Fergus County, Mont., was of the greatest assistance in the work. Knowing from the work of Stanton and Hatcher that the area north of the Missouri River and around the Bearpaw Mountains was one complicated in its geological structure by numerous faults and folds and areas of intrusive rocks, it was decided to begin the section far enough south so that if possible there might be no chance of error due to the occurrence of folding or faulting. We therefore followed the road leading a little west of north from Lewistown between the North and South Moccasin mountains to Deerfield, from which point we turned westward, reaching the Judith River about 40 miles above its mouth. This part of our course led us over the shales of the Colorado, as mapped by Calvert,¹ with a few outcrops of the underlying Kootenai formation showing on either side of the lower slopes of the Moccasins. The Colorado shales are well shown at Stough's ranch, having a thickness of about 1,000 feet overlaid by a sandstone referred to the Eagle. This is a massive white sandstone not over 100 feet in thickness in most places. As followed laterally it fades out into a yellowish sandstone which is somewhat shaly. This sandstone caps the bluffs on either side of Judith River, contrasting strongly with the underlying dark shales of the Colorado. Above it is an alternating series of massive yellowish sandstone and shaly beds reaching a total thickness of about 200 feet. A coal mine is worked in these upper sandstones about 2 or 3 miles east of the valley of the Judith River.

Above these supposed Eagle sandstones the beds are softer sandstones broken down and mainly covered. They are several hundred feet in thickness and undoubtedly represent the Belly River interval, but the outcrops were too meager to determine much in detail about them.

The dark-colored shales of the Pierre resting on these sandstones form the surface of the bench beginning several miles to the eastward of the coal mine, and the road to Kendall passes over them, several good outcrops showing, especially to the north of the road, but they do not show on the Judith south of the mouth of Warm Spring Creek. However, the Pierre shales appear in the

¹ "Geology of Lewistown Coal Field," *Bull. U.S. Geol. Surv.* No. 390, map.

valley long before Fullerton is reached and at the latter place form the bluffs on both sides of Judith River in typical exposures containing characteristic fossils. The entire thickness does not show at Fullerton but there is here an exposure of at least 400 feet. The total thickness is probably from 600 to 900 feet. Immediately below the Judith River beds which form the summit of the bluffs and the surface of the bench reaching to the eastward, there are from 50 to 100 feet of sandstone with *Halymenites major* and the following invertebrate fossils: *Avicula nebrascana* E. & S., *Tancredia americana* M. & H., *Lunatia subcrassa* M. & H., *Tellina equilateralis* M. & H., and *Macra* sp. These are identified by Dr. Stanton and referred by him to the Claggett, but it seems to me they are undoubtedly of Fox Hills age, the beds containing them resting on Pierre shales and being immediately followed above by the Judith River beds. The basal layers of the latter series contain *Ostrea subtrigonalis* and other brackish-water forms. The contact between the two formations as seen from the west side of the valley is somewhat irregular, suggesting the unconformity which elsewhere marks the upper limit of the Fox Hills and the base of the Lance formation. Up to this point no faults occur nor is there any evidence of folding nor of overturn. The section is normal and complete, unless a stratigraphic break exists corresponding to the paleontological hiatus at the top of the Fox Hills, the sequence from the Kootenai up through the Colorado and Montana into the Judith River formation being perfect except for the paleontologic and possibly stratigraphic hiatus at the base of the latter.

A short distance below Fullerton the first of three well-marked faults that occur south of Judith Landing crosses Judith River. The direction of this fault is nearly east and west and the dip of the beds thrown down is quite steep (about 20°) toward the northwest. This outcrop, mainly of Fox Hills sandstone and a smaller part of Judith River beds, is underlain by Pierre shales; and above the faulted beds are Pierre shales capped by Fox Hills sandstones (containing invertebrates and *Halymenites major*) which underlie the undisturbed Judith River beds which have a very slight inclination to the north or northwest. The lower slopes of the hill back to the faulted beds is composed of Pierre shales capped with Fox

Hills sandstones and overlying Judith River beds. This fault-line was afterward crossed twelve miles to the eastward near the crossing of Dog Creek. The second fault-line parallel to this one is exactly like the first, but the third one, a few miles south of Judith Landing, is a block fault of Fox Hills sandstones with a steep dip on the southwest side. From Judith Landing a trip up Dog Creek for about three miles above its mouth was taken to the point visited by Stanton and Hatcher and here another fault similar to those just referred to was seen showing, not only on Dog Creek, but extending across to the north side of the Missouri River. Lack of time prevented a tracing of these lines, and also precluded the close examination of the complicated conditions shown on Dog Creek.

That the structure is complicated is shown by the following conditions. In Plate 2, opposite p. 36, of *Bulletin No. 257* of the Geological Survey is shown a cliff of sandstone referred by Dr. Stanton to the Upper Eagle, which was found by him to be very fossiliferous, containing the following forms: *Cardium speciosum*, *Tellina montanensis*, *Baroda* sp., *Callista* sp. Cf. *C. deweyi*, *Mastra alta*, *Mastra formosa*, *Lunatia subcrassa*. This cliff was visited by us in July, 1911, and in horizontal beds lying below this cliff the following vertebrate remains were collected: *Champsosaurus* vertebrae, carnivorous dinosaur tooth, *Paleoscincus* tooth, Crocodile teeth, *Brachychampsa* (?) tooth, ganoid fish remains, and shark's teeth. These were identified by Mr. C. W. Gilmore of the U.S. National Museum, who says: "All of these forms may be found either in Judith River or the Lance formation with the possible exception of *Brachychampsa*, which at this time has been recognized only at Hell Creek and in the Ceratops beds of Wyoming." In the same series of beds 400 feet *higher* the following were found: carnivorous dinosaur tooth, a small ceratopsian tooth, *Trachodon* tooth, a turtle (not determinable), a crocodile (probably *Leidyosuchus*) and remains of a ganoid fish and shark's teeth. Below the lower of these two fossiliferous beds (both of which are regarded as of Judith River age) in beds standing almost on end the following invertebrates were obtained, viz., *Avicula nebrascana* E.&S., *Tancredia americana* M.&H., *Tellina equilateralis* M.&H., *Mastra* sp., *Lunatia subcrassa* M.&H., *Cardium speciosum* M.&H.,

Maetra formosa M. & H. These have been identified by Dr. Stanton, who says: "This lot is apparently made up of collections from two distinct horizons. The first five species of the list are from the upper half of the Claggett, the other two probably from a lower bed which may also be in the Claggett or possibly as low as the Eagle."

There is no mixing of horizons *stratigraphically*, as all of these specimens collected by the writer came from an area that can be included within one's outstretched arms, in which the exposure is perfectly shown; therefore they are *all* from the Claggett of Dr. Stanton, or, according to the writer, from the Fox Hills formation, as the species are found in the Fox Hills of Colorado and other portions of the Rocky Mountains. The fact that two of the species are mentioned as "possibly" of Eagle age and these two rather widely distributed in the Fox Hills raises the question as to whether the sandstones occurring so frequently along the Missouri River and supposed to be brought to the surface by faulting may not be of Fox Hills age rather than of Eagle age, especially as lithologically they are almost indistinguishable. It was impossible, as already intimated, to unravel the structure here in the few hours we spent at this locality.

Returning to Fullerton we crossed the county to the eastward, the surface formation until we reached Dog Creek being the beds of the Judith River formation. East of Dog Creek the faulting was again in evidence, beds of Pierre and Judith River age mainly being involved, although it may be found later that the Eagle sandstones and Belly River formation are present in some of the ridges. So much of the surface of this area is covered and the lines of the faulting so numerous (there being at least six of them separated by areas of Pierre shales) that no attempt was made to unravel the complicated structure. Until a complete areal survey is made, the structure here must remain obscure. At Mauland (now known as Boe's ranch), which is about 10 miles south of the Missouri and about 20 miles east of Dog Creek, well-marked exposures of Judith River, as determined by fragments of vertebrate remains, were seen at the ranch dipping steeply (20° to 25°) against a fault-line, separating them from the Pierre shales, which are

almost horizontal in this immediate place but only a short distance away are seen to dip gently toward the north or northwest beneath the supposed Judith River beds which cap the ridge. The relations of the Pierre and overlying Fox Hills in the latter outcrop were plainly seen, as they dip normally beneath the Judith River beds.

From this point we turned back toward Dog Creek, crossing it about eight or ten miles farther south than our crossing on the way eastward, and thence we returned to Lewistown. The principal result of this trip was the determination of the geological position of the true Judith River beds to be above the Fox Hills, verifying Stanton's observations of 1894, and confirming his original opinion that when the Fort Pierre shales—or, as he renamed them, Bearpaw shales—appear to lie above the *Judith River beds* it is due to faulting.

It was determined to examine next the supposed Judith River exposures in other areas mentioned by Stanton and Hatcher. Here again we went to the southward to avoid the complicated region about Bearpaw Mountains, especially as lack of time prevented our going northward to and beyond the Canadian line. The areas in Assiniboia are, according to the Canadian reports, of undoubted Belly River age, as described first by Dr. G. M. Dawson.¹ These beds were traced by Stanton and Hatcher to the vicinity of Havre, Mont., where they lie beneath Pierre shales without any unconformity or faulting. The first area visited by us was that on Fish Creek in which the section was gone over from the Jurassic up through the Cretaceous to the Fort Union. This section is essentially the same as that given by Douglas² and subsequently examined by Fisher. However, instead of finding Laramie resting on the Fox Hills, in which the characteristic *Halymenites* occurs, the beds lying immediately above were found to be of Livingston age with a typical flora, and between them and the undisputed Fort Union are good exposures of the Lance formation. It is, however, in the lower portion of the section that we are most interested. It is possible, as Fisher suggests, that the beds referred by Douglas to the Jurassic may belong to the Kootenai, as there is

¹ *Geol. Surv. Canada*, 1882-84, p. 116c.

² *Proc. Am. Phil. Soc.*, XLI, 207-24.

a lithological resemblance, but no fossils were found to prove this¹ supposition.

In these supposed Jurassic beds Douglas secured bones of a large dinosaur, above which he recognized several hundred feet of sandstones and shales, extending to the Benton, the upper part of which he says probably belongs to the Dakota formation. In the dark shales and sandstones which he refers to the Benton he obtained shells, all of Benton types. The Benton is succeeded above by grey sandstones and shales with some bands of limestone. He estimates these beds to have a thickness of 700 to 800 feet and refers them to the Niobrara, speaking also of the coal occurring above the middle. This coal and the beds below are probably to be correlated with the Eagle formation. In the upper part of the series not far below the top, I obtained a *Sequoia Reichenbachii*, probably the same species of *Sequoia* noted by Douglas as occurring near the same horizon in these beds. The beds so far as observed are nearly vertical in position, forming hog-back ridges, and the change to the badland beds, which are stratigraphically higher and nearly horizontal in position, occurs within a very short distance, though there is little doubt as to the two being conformable. These fresh-water beds are those which he calls the Fish Creek beds and he correctly correlates them with the Belly River beds of Canada with which their stratigraphic position agrees perfectly. They are overlain, as are the Canadian Belly River beds, by a great thickness of Fort Pierre shales. These exposures, first discovered by Douglas, are referred to by Stanton as follows:

Not being familiar with the Judith River beds, Mr. Douglas was unable to recognize the identity of the Fish Creek and Judith River outcrops. In their stratigraphic position, as well as in their lithologic and faunal characters, they are almost identical with the Judith River beds farther north and should be referred to that formation.²

As noted above, the stratigraphic position of these beds is the same as that of the Belly River beds in Canada and not that of the Judith River beds of Montana. There is of course a general resemblance lithologically in them to the Judith River beds and

¹ *Economic Geology*, III (1908), 83, 84.

² *Bull. U.S. Geol. Surv. No. 257*, 1905, p. 59.

also to those of the Lance formation. It was this resemblance, as we have seen, that in Canada caused the confusion between the Belly River beds and the Edmonton beds in the minds of Dawson and other Canadian geologists. McConnell,¹ referring to some of the fresh-water and brackish-water shells that are common to the two, says:

Their reappearance in the latter [Edmonton or Laramie] after a prolonged absence, during which the Pierre and Fox Hills—both marine formations—were deposited, affords an example of the extinction of a fauna over wide areas, its at least partial survival in sheltered localities, and the subsequent redistribution of some of its members over the same area on the recurrence of favorable conditions. . . . Vertebrate remains occur in part of this formation, and are strewn in large quantities over the faces of some of the sections. They are, however, nearly always in a poor state of preservation, and crumble to pieces when disturbed.

This faunal resemblance is noted by all the Canadian geologists. Whiteaves,² referring to it, says that from purely invertebrate paleontological evidence the Belly River, Laramie [Lance] and Judith River beds cannot be separated from each other. As to the vertebrate fauna, Professor H. F. Osborn, who has made a comparison of the land and fresh-water forms from these various horizons, says that there is very little in common between the Belly River fauna and that of the Laramie [Lance] of Wyoming and Colorado so far as described, and that most of the dinosaurs will probably be found to be separated generically.³ His table⁴ shows that of the 35 species accredited to the Belly River series only 9 are common to the Judith River. As to the resemblance between the Judith River beds and the Lance formation more will be said later on. There are no Ceratopsidae in common and this we find to be the case with the Belly River series in the Fish Creek section and in the Willow Creek section which was the one next examined by us.

On Willow Creek the section begins with outcrops of Benton shales. Above these shales is a series of sandstones and shales

¹ *Geol. Surv. Canada*, Vol. I, 1885, Montreal (1886), p. 65c.

² *Contributions to Canadian Paleontology*, U.S. *Geol. Surv.*, I, 55.

³ *Contributions to Canadian Paleontology*, III, Pt. 2 (1902), p. 10.

⁴ *Ibid.*, pp. 11 f.

exactly like those near Crawford's ranch on Fish Creek, which, there the same as here, dip beneath badlands exposures of Belly River beds, having a total thickness of about 180 feet. The Belly River beds, here, closely resemble those seen in the Fish Creek section and, like them, pass conformably beneath the soft dark shales of the Pierre, all dipping gently toward the southeast. The Belly River beds contain fossil wood in abundance near the base of the outcrops, and a few feet higher in the section the plants were collected which were described by Dr. Knowlton¹ and said to exhibit an undoubted relationship with the flora of the Dakota group and very little affinity with that of the Laramie or Fort Union as they would if from the true Judith River beds. There can be no doubt as to the Belly River age of these beds. They contain the usual fresh-water shells and the overlying beds contain a characteristic Pierre fauna referred by Dr. Stanton to the Bearpaw. The beds between the top of these Fort Pierre shales and the Fort Union horizon, from which a typical Fort Union flora was obtained and which Dr. Stanton says² "should, from their stratigraphic position, contain the equivalent of the Fox Hills and the Laramie as well as the Livingston formation," are of Lower Fort Union age—that is, are referable to the Lance formation. These (Lance) beds rest immediately upon the Pierre without any Fox Hills or Livingston beds between them, and as for the Laramie, no beds referable to this formation have yet been found in this region. A careful search was made for Fox Hills fossils, but not a trace could be found of them nor of anything referable to the Livingston, so, as at Forsyth, which was the last place visited by us, the Lance formation is in immediate superposition on the shales of the Fort Pierre.

¹ *Bull. U.S. Geol. Surv. No. 257*, 1905, pp. 129-55.

² *Ibid.*, p. 58.